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ABSTRACT

Resource allocation in universities is analyzed based on economic theory and a theory of organizational behavior in universities. Basic methods of reaching decisions regarding allocation are intuition and numbers and combinations of the two. The intuitive method assumes a university committee can judge its needs. The numerical method employs a measure such as the number of students. Numbers strongly tempered by intuition is the method emphasized. A university's financial situation determines which method is used. Numerical measures of staff needs include contact hours/job analysis, student load, staff/student ratio, and student load by size of department. A formula for computing staffing needs, the Orton line approach, and a comprehensive formula are discussed. Alternative methods for resource allocation are to make comparisons between universities and to make comparisons over time. Two types of reallocation, readjustment and major change, are discussed. It is preferable to base resource allocation on the number of students rather than on a measure of staff work. (SW)

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Occasional Paper 3

RESOURCE ALLOCATION WITHIN UNIVERSITIES

Based on a Seminar held on
27 February 1974

F J Orton
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Introduction

(a) Origins

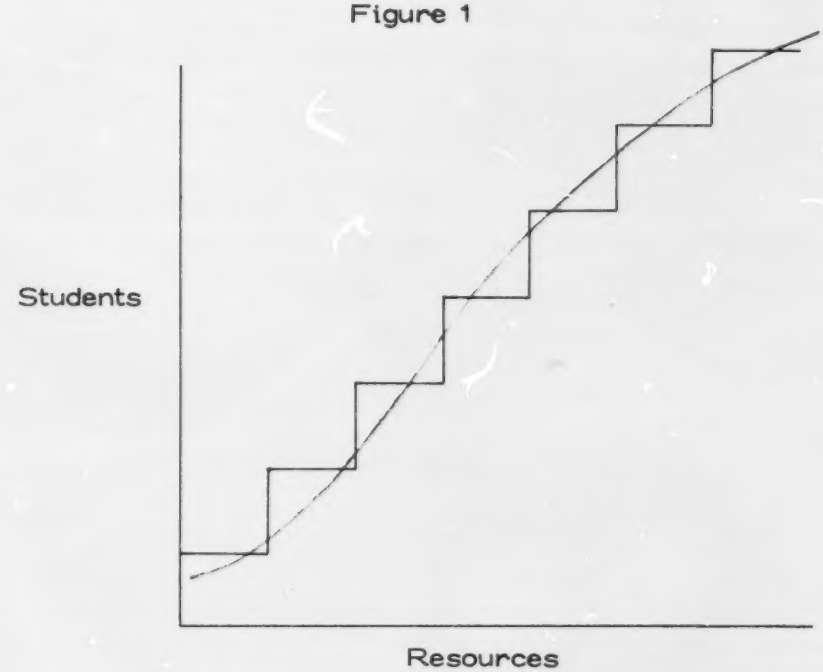
'The allocation of scarce resources among competing ends' is perhaps an old-fashioned definition of economics and this seminar could have been referred to the economic textbooks for the principles of resource allocation. While economic theory has much to say on this topic and my approach is developed from economic theory, this paper is based on a marriage of economics to organisational behaviour in universities.

The economic theory can be expressed in an oversimplified form in Figure 1. The general function can be expressed as:

Student Education = f (Resources)

This function oversimplifies because the word research is not mentioned - a major omission in a university context.

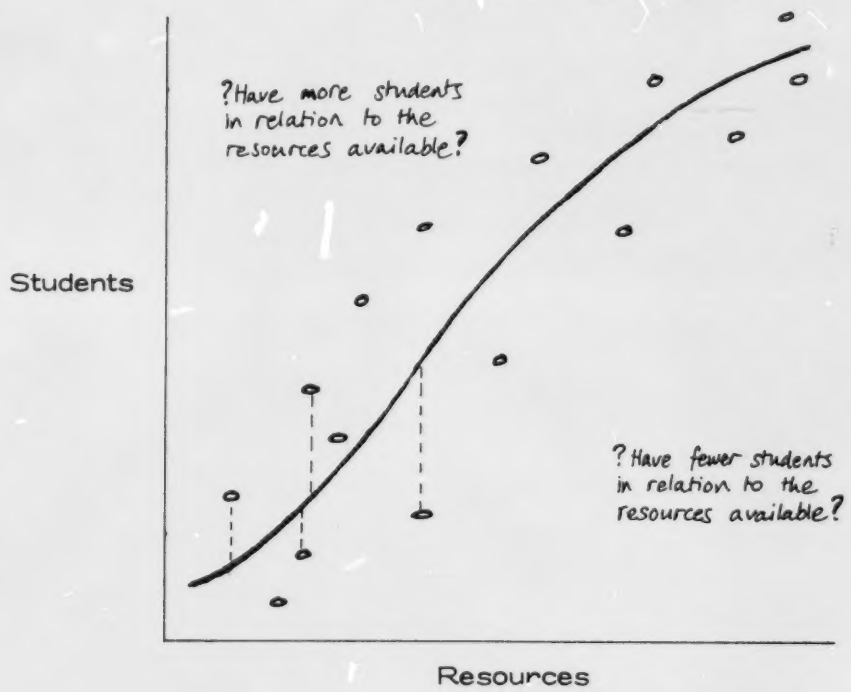
Figure 1



The continuous line in Figure 1 also oversimplifies the position as most resources are supplied in steps: new buildings, new staff, new equipment, while only departmental grant can be regarded as a continuous function. The graph shows in the lower section increasing returns to scale, in the middle section constant returns and in the top section decreasing returns.

By plotting resources by students and drawing a regression line of best fit through the data (Figure 2) it is possible to find out which departments are well provided and which are badly provided. We will come to the use of this theory later.

Figure 2: SIMPLE MODEL


?Have more students in relation to the resources available?
Students
?Have fewer students in relation to the resources available?
Resources

I do not wish to discuss the theory of organisational behaviour in universities in detail. There are almost no textbooks and few articles on the subject, but I am assuming that in the discussion those at this seminar can supply the deficiency.

(b) Extra and Reallocation

It can be noted that a new word has already crept into the introduction - "scarce". I will introduce the word "extra", but since being asked to give the talk upon which this paper is based a deep freeze has descended on the university scene. I had planned to talk mainly on allocating extra resources with an ending reference to reallocation. In the light of the present economic situation the balance of the two topics should perhaps be readjusted.

Methods of Allocation

There are two basic methods of reaching decisions regarding allocation: Intuition and Numbers.

a. The intuitive method assumes that any committee worth anything knows enough about departments in the University to judge their needs. The theory is put forward that this method has worked well in the past and everyone is happy. The man who shouts loudest and sometimes longest gets most.

b. The numberical method employs such measures as the number of students and the number of staff contact hours. There are a great variety of measures which I will discuss later.

We may distinguish two other methods, the natural sons of the first two. They are Numbers tempered by Intuition and his twin (though not an identical twin) Intuition tempered by Numbers. The combinations of the two basic methods are justified on the basis that statistics are not a substitute for reason - they are a help to reason. It is a fallacy to imagine that numbers can cover everything. These four methods can be expressed on a scale (Figure 3). An enormous range on that scale is found throughout the universities and dissatisfaction is found with each method. Which of the methods is used will depend to some degree on the financial situation of the times.

Figure 3

Ample Extra Resources	Intuitive ?
Scarce Extra Resources	Intuitive/Numerical
Very Scarce Extra Resources	Numerical/Intuitive
No Extra Resources	Numerical
Retrenchment	Numerical
Gross Retrenchment	???

As resources become scarcer there is a move towards the numerical end of the scale. If the institution has enough finance to cover everyone's reasonable needs, the pressure for the use of a numbers method is less.

If the institution has just enough for its reasonable needs, the pressure for a numbers exercise becomes greater. If the institution is really short of resources the case for a numbers exercise, even if still balanced with intuition, becomes nearly overwhelming. If reallocation has to occur, then some form of statistical appraisal becomes essential. In Figure 3 gross retrenchment is entered with a question mark. In that very difficult economic situation numbers may be only one factor influencing cutback. This question will be considered further under reallocation.

Intuition

The intuitive method can be defended on the following grounds:

a. loud shouters satisfied
b. even allocation of different types of resources
c. helps injection of new developments
d. major changes of policy more possible
e. encourages excellence

If the university relies on "he who shouts loudest will receive" the resources from various allocating processes will tend to come in about the right proportion. The department that can shout loudest for staff can also shout loudest for equipment and departmental grants; so a matching of overall allocation can be achieved. The numerical method is best developed in some areas, for example, academic staff, than in some others and can lead to imbalance. The intuitive/numbers method can also lead to difficulties with unmatched allocations occurring.

Numerical exercises cannot indicate whether there should be major new developments and may not indicate early enough the need for major changes in policy. Excellence cannot easily be expressed by numbers though Chemistry departments are beginning to develop citation indices to indicate their relative excellence.

In time, however, the numerical approach or the numerical/intuitive approach will be refined and in the present economic situation has an enormous amount to commend itself. It has already been suggested that the numerical or numerical/intuitive method is essential to reallocation. I would like to qualify this: the allocation can be done in two ways: readjustment of resources at the margin by transferring one post from department A to department B, or major change of policy: is department X needed at all? The second form of reallocation, which is a rare one, could of course be undertaken without a statistical analysis.

Numbers

The supporters of the use of numbers might argue that:

a. they reduce time spent arguing
b. they are less devisive than intuitive methods
c. they support those who cannot necessarily argue strongly
d. they are administratively tidy

The allocation or reallocation by numbers alone ensures that the reallocating is done with the minimum of argument which is time-consuming and devisive. A procedure can be devised whereby the major argument concerns the principles involved in calculating the numbers; when these have been agreed the operation of the principles is left to the administration. Experience of long arguments about lapsing of minor posts, expert cases presented by able deans and decided not entirely on the merit of the case, the natural reluctance of academics to be unkind to their fellows and administrative tidy-mindedness might lead some of us towards a hankering for a purely numerical system.

Numbers by intuition

On the other hand, let us hope that many of us have very strongly engrained the principle that statistics are an adjunct not a substitute for reasoning. Even if a correlation is significant at the 1% level, there may still be a 1 in 100 chance that it is not significant. Nonsense correlations can occur, e.g. the number of clerical staff in departments may be correlated with the size of that department's grant. Is this because of the heavy clerical work required in ordering, or the common factor of the ability of the head of department to shout loudest to two committees? It is a fallacy that numbers can measure everything and on that basis intuition must enter the argument. The desirability of the two alternative methods can make the basis of a very fruitful discussion.

Types of numerical method

Let us consider first measures for staff needs. There are four main criteria:

a. { Contact hours
   { Job analysis

b. Student load
c. Comprehensive approach
d. Student load by size of department

each of which has strong advantages and weaknesses.

(a) Contact hours/Job analysis

This method measures the tasks which staff actually do. In its simplest form the number of hours that academic staff spend directly facing students in a teaching situation is used; in more sophisticated models the hours spent on preparation, marking, examining, setting papers and so on are also included in the calculation.

For technical and clerical staff complicated systems can be developed which measure the work load of staff, e.g. for clerical staff measures can be made of the number of pages typed, the number of documents received, the time spent on filing and so on.

Advantages

The measure represents the work staff actually do. The contact hours measure can take account of different methods of teaching, is used in some other sectors of higher and further education besides the universities and has an obvious appeal to staff who are keen to teach; it emphasises teaching at the expense of research and encourages hard work.

It can be adapted to take account of a wide variety of other factors besides lecturing hours, e.g. tutorial time, time spent in marking essays, time on administration and so on. (The alternative measure of student numbers does not reflect sufficiently the problems of small departments.)

Disadvantages

Because it is such an obvious system, a sceptic will have to ask what is wrong with the approach.

The contact hours method does not recognise Parkinson's Law. Although it measures the amount of work done,

it does not measure how necessary that work is. Has the work expanded to fill the time available?

The method encourages small classes and the proliferation of options.

Student contact hours measures require uncheckable information from departments and the method places an extra administrative load on a department asked to provide reliable information. Staff contact hours are difficult to measure. For example, time for preparation varies widely and hours of staff supervision of laboratory/studio work actually in progress can also vary. A member of staff, for instance, may be sitting in his room working on some other matter on call to students rather than actually working with them in the laboratory.

The main criticism, however, is that the system encourages over-teaching and research is discouraged. The UGC pays universities broadly on the basis of numbers of students and there seems some logic in having the allocation process within the university reflecting the method by which the institution itself obtains the money. The contact hours method can also lead to central interference in the way departments teach.

Conversely, where the contact hours system is weak, the student numbers calculation is strong, but the student number system would be considerably strengthened if clear differences of student/staff ratio could be established between subject groups. There are various figures available but the extent to which these are a reflection of current practice rather than real need is doubtful.

(b) Compromise

Obviously some compromise system is the most desirable and I would like to suggest two: a comprehensive formula, and 'the Orton line'.

Comprehensive formula

The first compromise system is the use of a formula resting on the principle that the Staff/Student Ratio

$$= \frac{\text{Average Student Contact hours}}{\text{Average Class Size} \times \text{Average Staff Contact hours}}$$

e.g. 99 students
9 members of staff
5 groups of students
10 average student contact hours per week

} Ratio $\frac{9}{99} = \frac{1}{11}$

$$\frac{1}{11} = \frac{9}{99} = \frac{10 \text{ (Av. Student Contact hrs. per week)}}{\frac{99}{5} \times \frac{5 \times 10}{9}}$$

$$\text{Av. Class Size} = \frac{\text{No. of students}}{\text{No. of classes}}$$

$$\text{Av. Staff Contact hours} = \frac{\text{Total no. of classes}}{\text{Total no. of staff}} = \frac{5 \times 10}{9}$$

This shows the management data required to give the position about the academic staff in a department.

Each of these three variables is perhaps easy to measure in a school situation but is much harder to define in a university situation. What is the average class size for a laboratory class in which the students are expected to spend all their time with no formal classes? When a member of staff is available for consultation while the students work in the laboratory, how many staff contact hours does this represent? How is the formula used for the postgraduate situation? In spite of all these difficulties the formula does provide an interesting insight into the whole resource allocation process.

The real criticism, however, of such a collection of statistics is two-fold: firstly, the cost of producing this wealth of information may be greater than the benefits gained. The collection of statistics consumes resources

that might be better spent on teaching and research. Second, the freedom the UGC gives universities to deal with their resources in the way they think best is a welcome departure from over-central control. The same principle should apply when central university committees deal with departments. Once a department has been given its resources, or a staff/student ratio, decisions about how to teach, what size of groups to teach in, how many contact hours staff and students should have, should be decisions for the individual department. Can administrators decide how to teach Mongolian Literature? If the Professor of Mongolian Literature states that it should best be taught in tutorials of two students to one member of staff with no lectures, then on what basis can an administrator argue? Can a Professor in another department argue either? If, however, the Professor of Mongolian Literature is given a student/staff ratio within which to operate he can still have his small classes but either staff must teach more hours or the number of student contact hours must be reduced. The department can take the decision.

Orton line

Having discarded this comprehensive formula on the basis of cost and possible inapplicability in the university situation, other approaches have to be found. The contact hours technique is mainly favoured by small departments who find they have to run very hard when the staff/student ratio is standardised throughout the university. Small departments usually have small classes through no fault of their own and it takes as long to lecture to a small class as to a large one. There are after all some economies of scale in higher education. I would therefore like to commend use of a table of comparative staffing or the Orton formula.*

*Apology is perhaps due for the use of a named formula. When first given this name, the author resisted its adoption but as time has progressed the naming has been shown to have advantages. Academics can blame the formula and its author and live in peace with each other.

The example given below is from the imaginary University of Middle Mongolia. This University cannot be accused of bearing any relationship to any real university in either the eastern or western world.

The University of Middle Mongolia

The following table (Figure 4) shows the number of students (weighted) and the number of academic staff which has been calculated by making allowances for part-time staff, including part-time demonstrators and tutors.

Figure 4

Department	Staff Equivalents	Student Equivalents
Astrology	4.9	163.68
Astronomy	7.3	291.28
Soil Science	11.0	204.45
Plant Physiology	5.9	105.66
Animal Physiology	7.3	84.38
Animal Behaviour	5.4	28.87
Milk Purity	5.6	30.27
Milk Production	8.5	144.95
Pig Production	8.0	151.92
Camel Production	7.3	126.24
Crop Husbandry	7.9	55.47
Veterinary Science	8.7	213.41
Poultry Production	8.1	125.72
Farm Buildings	10.6	219.83
Farm Mechanisation	7.3	68.85
Water Production	10.0	199.93
Forestry	7.9	196.77
Textiles	9.4	72.54
Paper	7.6	87.05
Mining	7.7	23.40
Wood Science	8.2	209.19
Agricultural Economics	10.6	184.99
Urban Design	8.3	52.41
Rural Sociology	9.7	39.79
Agricultural Marketing	11.2	113.73

Figure 4 (cont.)

Department	Staff Equivalents	Student Equivalents
Indian History	11.8	110.23
Sanscrit	2.1	3.55
Anglo Saxon	5.9	22.67
Buddhism	9.6	48.31
Mongol Language	12.7	75.96
Mongol Literature	14.1	157.45
Japanese	7.7	110.28
Chinese	8.2	64.20
Korean	4.5	45.86
English	5.2	28.05
War Studies	9.9	139.73
Drama	11.0	46.80
Confusianism	7.4	51.63
Conformism	12.0	141.93
Speed Reading	6.2	18.67
Leninism	9.3	86.22
Agricultural Policy	11.3	351.62
Land Use	10.7	236.74
Canadian Studies	2.9	25.22
Maoism	8.7	117.91
Affluence Control	10.7	172.95
Communist Practice	13.5	317.70
Brain Washing	12.8	322.73
Museum Technology	9.3	79.31
Agricultural Statistics	10.1	238.56
Abacus Methods	11.1	388.44
Mathematics	10.1	176.34

The larger the department in terms of academic staff the less favourable is the staff/student ratio. This relationship is significant at the 5% level and is used to calculate the table of comparative staffing (Figure 5). This table has been drawn on the assumption that the first equation is only relevant for departments with from 1 to 30 members of staff. Another equation, which assumes that there are no more economies of scale, and that all additional students above 298 are taught at a student/staff ratio of 1/12, is used to determine the place of large departments on the table.

Figures are provided as an aid to, not as a substitute for, reasoning. The table and the figures on which it is based have never been used slavishly and the Committees that use them have always regarded them with a healthy scepticism.

The effect of amalgamation of departments into schools or of separation into smaller units does have an effect on the place in the table. If the units are already fairly large the result of amalgamation is not striking but when very small units amalgamate the change in position can be pronounced and may possibly over-state the real favourability of the department concerned. If Mongol Language and Mongol Literature amalgamated, however, they would still be at the top of the table.

It is important to realise that although all departments are placed in an order there is a wide area of uncertainty. For instance, while it is possible to suggest that there is a significant difference between departments in the centre of the table and those at the extremes, the analysis does not in any way prove that there are real differences between different departments close to each other in the table.

In the past the table of comparative staffing has given the proportional difference in numbers of staff between departments. The information in the table has been extended to give the actual numbers of academic staff which a department has over and above or less than the mean figure for a department of that size.

For instance the Department of Land Use has 237 weighted student-equivalents and 22¼ academic staff-equivalents. From the equation given on the page after the table of comparative staffing the predicted number of staff for a department with this number of students is 24¾ academic staff-equivalents and hence Land Use is shown as 2½ members of staff short (this figure is entered as -2½ in brackets on the table of comparative staffing).

The table itself shows the proportional difference between departments, e.g. Buddhism is 1 post short in a total of 5 staff, i.e. 20% short; Land Use is 2½ posts in a total of 22¼ posts, i.e. 10% short. It is for the Committee to decide, if need be, whether Department A which is 20% short on 5 staff is in more need of staff than Department B which is 2½ short on a total of 22¼ posts.

Figure 5

TABLE OF COMPARATIVE STAFFING

More students to staff than average

Mongol Literature(-6)

-5

Mongol Language(-3)

-4 Communist Practice(-8)

Indian History(-3½), Conformism(-4)
Drama(-1½), Brain Washing(-7)

-3

Agricultual Marketing(-3)

-2 Rural Sociology(-1)
Buddhism(-1), Soil Science(-3)
Affluence Control(-2½)
Agricultural Economics(-2½), Agricultural Policy(-3½)
LandUse(-2½), Farm Buildings(-2½), Textiles(-1)

-1 War Studies(-1½), Museum Technology(-1), Mathematics(-1½)
Leninism(-1), Abacus Methods(-2½)
Water Production(-1½), Agricultural Statistics(-1)
Urban Design(-½)
Mining(-)

Chinese(-)
Maoism(-)
Crop Husbandry(-)
Milk Production(+1), Confusianism (+½)
Poultry Production (+1½), Veterinary Science(+2)

+1 Paper(+1), Japanese(+1½), Farm Mechanisation(+1)
PigProduction(+2), Speed Reading(+½), Animal Physiology(+1½)
Food Science(+3½)
Forestry(+4)
Anglo Saxon(+1), Camel Production(+3)

+2

Milk Purity(+1½)
Animal Behaviour(+1½)
English(+1½)

+3

Astronomy(+10½), Plant Physiology(+6)

+4

Korean(+4½)

+5

Astrology(+15½)
Sanscrit(+2), Canadian Studies(+5)

Less students to staff than average

Explanatory notes:

The figure in brackets after each department is the number of posts (to the nearest half) short or in excess of the staff required for the student-equivalents of that department to bring it to the University 'mean'.

The vertical axis measures the difference between the actual student-staff ratio and the ratio predicted on the basis of the number of staff in a particular department.

For t = 1 to 30

$$\frac{s}{t} = 0.64\ \sqrt{t}\ + 6.41 \quad \text{.....Equation 1}$$

For departments with more than 30 staff the equation above applies until t = 30 when the following equation is used to consider the position above 30 members of staff:-

$$s = 12\ (t - 30) + 298 \quad \text{.....Equation 2}$$

(t = number of academic staff equivalents
s = number of student equivalents)

The formula suggests that as a department gets larger the student/staff ratio should also get larger. The larger departments can cope with more students per members of staff than can the small ones. It was found that the student/staff ratio was a function of the number of staff in the department. This measurement was made at the time when the decisions about the allocation of resources were taken on intuition, so originally it was not a self-fulfilling prophecy. The particular equation used with a square root term helps measure the concept that most of the economies of scale are achieved by the smaller departments. This reflects the UGC view about viable sizes of departments - by viable is meant that there is little economy of scale left.

This formula has used the economic theory discussed at the beginning of this talk. The Orton formula uses the concept of increasing returns for small departments and constant returns for the medium-sized. The University

of Middle Mongolia has no very large department of, say, 60 members of staff, so does not need at this point in time to devise a formula to reflect diminishing returns. The Orton formula is, perhaps, relatively complex, so the following table gives a simplification:

Figure 6

University of Middle Mongolia

Normal staff/student ratios for various sizes of department measured by number of staff

Number of staff	Departmental overall Student/Staff ratio	Weighted Student Equivalents
1	7.1	7
6	8.0	48
11	8.5	94
16	9.0	144
21	9.4	196
26	9.7	252
31	10.0	310

The staff numbers include an allowance for part-time demonstrators and the student numbers include weightings for postgraduates and clinical students (first year postgraduates in Science 2, first year postgraduates in Arts 1.5 and for all clinical students 1.6). Academic posts below the level of Lecturer are counted as one half.

This shows that a small department has to have approximately eight extra students to justify one member of staff. The larger departments have to have eleven or twelve extra students to justify one.

Criticisms

The question that can be asked is "Does the Orton formula favour the small departments too much?" Used on its own, it probably does not, but used in conjunction with what I have called intuition, it probably does. The formula tries to take account of small departments' arguments. A large department with 30 or more staff would find it very difficult to argue that it has no one to teach a particular specialisation in the subject. But how often does the small department argue that the department wants to develop some particular option and needs extra staff to do it? Small departments' arguments on top of the advantage given by this formula can lead to an excess of posts being given to small departments.

The technique assumes almost all departments of the same size should run on the same student/staff ratio. It is interesting to note that most of the departments needing more staff by the formula are arts based. It is not until one gets to the department called 'soil science' that one finds a department that is science-based in Figure 5.

The regression line is drawn between different departments of different type. This can be a serious criticism.

Inter-University comparisons

The alternative is to make comparisons between universities, taking not necessarily universities of the same type but subject groups of the same size. Comparisons between universities are fraught with difficulties. The statistics are not necessarily collected on the same basis by different universities. By making a comparison based on arithmetic means of different universities, is there then a strong pressure to come to those means? Student/staff ratios are very favourable in some subject areas not because this is the right ratio but because there is a dearth of students after a period of plenty for which the department

is staffed. Volume 6 of the D.E.S. Statistics of Education gives details of load and expenditure by subject group only. This is of limited value in a university divided on a departmental basis.

Comparisons over time

To overcome some of the criticisms of the Orton line approach, comparisons of a department's student/staff ratio over time can be used. I could quote examples where the student/staff ratio has changed from 1:9 to 1:6½, an unfavourable figure to a favourable one over seven years. This of itself is no proof that the department is now overstaffed but the figures can be one useful guide in the argument.

Reallocation

There are two types of reallocation which I wish to discuss: (a) Readjustment and (b) Major change.

(a) Readjustment

At the present time the shortage of resources in universities will lead to departments unfavourably staffed asking "When will our difficult position ever be resolved?" The only way to alleviate the problems of the poorly off will be either by the departments at the top of the table taking fewer students and those at the bottom more, or by transfer of vacant posts from one area to another. The usual reason why departments are at the bottom of the table is that they cannot attract enough students because of a national shortage in that subject, so reallocation of intake quotas is particularly ineffective. Therefore the only way to make progress is to review all vacancies in the well-staffed departments.

This paper is not able to cover in detail the various ways of reallocating resources but two main points stand out. The political will to make reallocations is essential. This political will is much stronger in a period of financial stringency than in a period of plenty. The task can be undertaken better by the uninvolved. The Committee concerned should be comprised of members of departments who are averagely to slightly poorly staffed. To construct the Committee of those from well staffed departments will be unlikely to lead to reallocation. To place many of those from badly staffed departments on the reallocating Committee may leave a taste of unfairness when the task is complete.

(b) Major change

For a major reallocation when a department has to be closed, the main principle, I hope, will remain that redundancy should be avoided. After all knowledge is indivisible and men can teach and research in the nearest department to their own. Retraining also must not be ruled out. Again, the uninvolved should be entrusted with the task - the enquiry Committee should not have on it either any staff of the department under scrutiny or any staff of a department which might benefit directly from the breakup. All these staff can be seen and given a hearing but they should not be involved in the decision if the Committee is both fair and seen to be fair.

Summary

This paper has emphasised the importance of numbers strongly tempered by intuition as the main basis for resource allocation.

The numbers of students involved rather than measure of the work which staff do is to be preferred.

Reallocation will develop when needed in the light of the financial situation.